Computational Vision Systems and Applications of Pattern Recognition

Special Session along with PATTERNS 2017, February 19-23, 2017 - Athens, Greece
https://www.iaria.org/conferences2017/PATTERNS17.html

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Abstract—**Computational vision systems and applications of pattern recognition have infiltrated into various fields as an important technology. All processing systems by computers are designed as efficient as possible for the intelligent performances. Computational vision often seeks to actualize human vision system for the intelligent performances. Nowadays, these technologies enable to recognize two-dimensional patterns, inspect failure and quality of substrate, detect and track human motion, recover the 3D shape from input images, etc. Then, applications of pattern recognition bear an essential part of these technologies. This session includes intelligent processing, artificial neural networks, an intelligent operation for application, computational vision processing with learning approach and cognitive processing including actual applications of pattern recognition. A special session on Computational Vision Systems and Applications of Pattern Recognition is included in Pervasive Patterns and Applications (PATTERNS) 2017 conference, held in Athens, Greece. Four papers address the challenges on the topics of computational vision systems and applications of pattern recognition that are important subjects to solve at present.**

Keywords–Virtual Reality; Shape from Shading; Point Light Source; Perspective Projection; Camera Calibration; Reflectance Parameter; Polyp Classification; Endoscope Image; Voting Processing; Pre-Trained Network; Convolutional Neural Network; Support Vector Machine; Defect Detection; Defect Classification; SURF.

I. INTRODUCTION

Four papers are presented in this session COVAPR. Each paper treats the reent research topic in virtual reality, shape recovery, feature extraction and pattern classification in actual problems and/or medical image analysis.

A. Estimating Patterns and Application to Virtual Reality

Virtual Reality (VR) is the rapidly growing research field in recent years. VR technologies give us various merits. There are simulators to practice an operation and to fly a plane as examples of VR technologies. These simulators can enable us to avoid the risk and to save the cost. VR researches that targets to households also have been attracted. A data glove is one of the major interfaces which are used in the field of VR. It measures curvatures of fingers using bend sensor. In order to obtain accurate hand motions, it is necessary to use a data glove which has many sensors, but it is expensive. It is preferable that an interface is small scale and low cost. Various types of researches about data glove have been conducted. On the other hand, there is a low cost data glove which measures an angle for each finger through one sensor. But it cannot get detailed data directly. For example, the 5DT Data Glove 5 Ultra and DG5 VHand have a single sensor on each finger, so they have five sensors in the whole hand. However there are three finger joints for each finger, a single sensor can not measure all of these three angles directly. In our laboratory, we have proposed the method to get plausible user hand motion pattern from the low-cost glove. This method estimates the kind of hand motion patterns using each relation among angles of fingers during operation. Then it estimates all finger joint angles by estimating the types of hand motion patterns from the correlation between each finger angle in the hand motion pattern. We assume some representative hand motion patterns, and consider that other hand motions can be represented as synthetic motion of them. And we calculate the ratio of each representative motion pattern. Moreover estimating each finger angle using the result, we express any hand motion patterns other than the representative hand motions. However we have used 5DT Data Glove that sensors cover two joints of each finger. Thus, we try to estimate finger joint angles when using the data glove; DG5 VHand that sensors cover only middle angle of each finger.

B. Recovery of Absolute Size and Shape of Polyp Using Medical Suture

The size of a colonic polyp is a biomarker that correlates with its risk of malignancy and guides its clinical management. Given this central role of polyp size as a biomarker, the precision and accuracy of polyp measurement is an important issue. In addition, advanced adenomas are those that are larger than 1cm or that contain appreciable villous tissue or high-grade dysplasia. Therefore, obtaining polyp size and shape is important for the precise diagnosis. For these situations, it becomes more important to develop the medical supporting application of computer vision in the medical field, where the 3-D shape reconstruction is tried to be used in the medical diagnosis. As a 3-D shape reconstruction technology, Shape from Shading (SFS) is one valuable approach of 3-D reconstruction. SFS uses the image intensity directly to recover the surface orientation of a target object from a single image. Based on SFS, some approaches have been proposed to recover polyp shape from endoscope images. An approach has been developed using both photometric and geometric constraints assuming one light source of endoscope. Another approach recovers polyp shape assuming more actual endoscope, which has two light sources, and it uses neural network to modify the obtained surface gradients. Those polyp shape recovery approaches based on SFS assume a Lambertian image and need some parameters such as a depth parameter Z from endoscope lens to the surface point. To obtain the depth Z, another approach has been developed using two images using medical suture between the movement of Z direction in endoscope video under the assumption of one light source. To relax the constraint for shape recovery, this paper proposes a novel approach for obtaining depth Z and surface reflectance parameter C from a single endoscope image of medical suture. Medical suture is used to estimate its horizontal plane locally and observation model of medical suture is used with the horizontal plane. In addition, two light source endoscope is assumed to improve the accuracy of polyp shape based on the actual endoscope. Experiments of polyp shape recovery are demonstrated with the estimated parameters and it is shown that polyp shape is recovered with its absolute size.

C. Polyp Classification Using Multiple CNN-SVM Classifiers

Polyp diagnosis using endoscope in the medical scene is conducted actively along with increasing of the prevalence rate of colorectal cancer. There are various forms of polyps, such as protuberance type, surface flat type, surface recessed type and so on. These shapes are used as a reference when judging the malignancy/benignity of polyps. However, it is difficult to judge benign/malignant only by shape in some polyps, and the diagnostic result of polyp using endoscope depends on the experience of the medical doctor. There are many cases where correct diagnosis is obtained by the medical doctor as the pathological diagnosis judges correctly. Therefore, it is necessary to develop the computer-aided system with computer vision technology to eliminate difference of diagnosis results from the experience of doctor and to reduce the burden of medical doctor. As a method to judge the malignant/benign polyp from endoscope images, some methods have been proposed. In some methods, ultra-high magnification endoscope is used for the polyp diagnosis with high precision. The ultra-high magnification endoscope has higher magnification than regular endoscope and it enables the diagnosis at the cell level. However, it requires many times of diagnosis when ultra-high magnification is used and it would give the patient some burden. Therefore, this paper proposes a method to classify malignant or benign polyp using regular endoscope images. Actually there are many non-polyp scenes in endoscope video of the regular endoscope, which makes it difficult to classify the malignant or benign polyp. Therefore necessary conditions are that only the polyp images are used as the target of proposed method. Some methods were proposed for polyp detection based on rectangles. While there are three types of images which are taken by the regular endoscope: with white light, dye and narrow band image (NBI) in general. These three kinds of images have different characteristics and the difficulty of classification level of malignant or benign polyp depends on the condition of each image. In the proposed method, polyp region is extracted based on such rectangle based polyp detection methods and three types of images taken by the regular endoscope are used for the classification. Accurate classification of malignant or benign polyp are tried from each image features for supporting the medical diagnosis.

D. Defect Detection and Classification of Electronic Circuit Boards

Electronic circuit boards are used as components of the various precision instruments such as computers and liquid crystal displays. Each layer is inspected after drawing and baking the mask pattern in the manufacturing process of the electronic circuit boards. There is Automated Optical Inspection (AOI) as a computer assisted inspection. The defect is judged from the loss rate of the lead wire portion in AOI, but the final goal is that defect is judged whether the true defect as a product or the pseudo defect as a product. It is necessary to perform high accuracy in those inspections. Present AOI needs ”verifying” by human eye check to judge the exisitence of the final defect after AOI. Human cost and variability of inspection accuracy originated from individual checking ability are problems in verifying process. It is hoped to reduce this cost and to keep the accuracy for inspection with computer-aided defect inspection. Defect types during the inspection consist of true defects and pseudo defects. True defects include chipping, breaking, protrusions, shorts, etc. True defects cannot be shipped as the products when these defects are found. On the other hand, pseudo defects have foreign matter adherence and stains and these can be removed after inspection. So pseudo defects can be shipped as the product. If a true defect is erroneously classified into a pseudo defect, it becomes problem. If a pseudo defect is erroneously classified into a true defect, it becomes discarding the normal product and leads to reducing Normal products are disposed when a pseudo defect is erroneously classified as a true defect, and it causes reduction of yield rate. Some approaches have been proposed to solve these problems using image processing. A global defect inspection of defects is proposed by learning using Mahalanobis distance. As another approach supplies a current to the electronic circuit boards, and the defect is detected from the radiation position from the radiation infrared image by taking advantage of the characteristic that the short portion generates heat due to the leak current. Various approaches are also proposed for the defect classification. An approach classifies defect type using its shape informationunder the assumption that reference image is used for the classification. An approach detects a candidate region of defect by taking difference between reference image and test image. Feature quantities are obtained from the candidate region and two classes classification of true defects and pseudo defects is proposed using SVM. The data classification is performed by constructing multi-subsets and classifiers using features by random sampling of the dataset and taking a majority vote, and the stable accuracy is obtained if the number of learning data is sufficient. However, it is necessary to prepare the reference images in inspection. The creation of the reference image requires positioning in units of pixels, and it costs much to create a reference image for each inspection image. An approach proposes a defect classification method using Bag-of-Features as a method without using a reference image, while this paper deals with AVI (Automatic Visual Inspection) which is available to the simpler patterns of electronic circuit boards. The method cannot be directly applied to AOI. The proposed method tries to improve the accuracy of detection and classification using features obtained by Convolutional Neural Network (CNN). The candidate defect region is extracted without reference image by keypoint extraction in defect classification, and features are extracted by inputting the cropped region into the CNN.